CORELIS

TAP Expander

TAP Expander
Blackhawk Emulator Expansion Pod

User's Manual

Document Part Number: 70397 REV B

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New editions are complete revisions of the manual. Update packages, which are issued between editions, contain additional and replacement pages to be merged into the manual by the customer. The dates on the title page change only when a new edition is published.

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Revision A, May 2008
Revision B, February 2011

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Chapter 1
Product Overview

Introduction

The TAP Expander pod is an add-on accessory that enhances the functionality of a Blackhawk JTAG emulator to support daisy chaining up to four scan chains and allows the emulator to connect to a unit under test (UUT) with multiple TAP connectors. The TAP Expander internally routes the JTAG signals to the appropriate TAP connector. This allows signal integrity to be maintained when chaining TAPs and boundary-scan test coverage to be increased by allowing the interconnections between the different TAPs to be tested. The TAP Expander is operated under host software control and is compatible with the Corelis ScanExpress boundary-scan and functional test tools and all the various Blackhawk JTAG emulators

By coupling the power of the ScanExpress boundary-scan tools with that of an emulator, a complete and integrated solution is now available that offers the best advantages of both boundary-scan and functional test methodologies.

Boundary-scan (JTAG) operates as the complementary companion to functional testing. Boundary-scan is the preferred solution for testing areas of printed circuit board assemblies that are difficult to access due to physical space constraints and lack of physical access, which is often due to fine pitch components such as Ball Grid Array (BGA) devices. The functional tests are executed at the processor speed and may be able to detect board level faults such as a cold solder joint between the processor and a memory pin that boundary-scan will not. Additionally, the functional tests may check non-boundary-scan compatible portions of the unit under test (UUT) such as UARTs, ADCs, DACs, and I2C peripherals.

The TAP Expander module is shown in Figure 1-1.

Figure 1-1. TAP Expander Module (Top View)

What is IEEE Standard 1149.1?

The TAP Expander facilitates software-controlled boundary-scan operations per IEEE Standard 1149.1. It provides command access to the target's Test Access Port (TAP), accessing device internal registers and on-chip debugger, verifying PCB interconnects, performing functional testing, and debug without manual probing. The JTAG interface also provides access to internal device functions that are not accessible via external probing, enabling fault isolation within the device itself. The JTAG interface also enables programming target Flash and CPLD devices, as well as data download and uploading to and from the target memory devices.

The TAP Expander is often used to perform microprocessor emulation via the device JTAG port. It is used for firmware development providing single-step, break, and content update/visibility access.

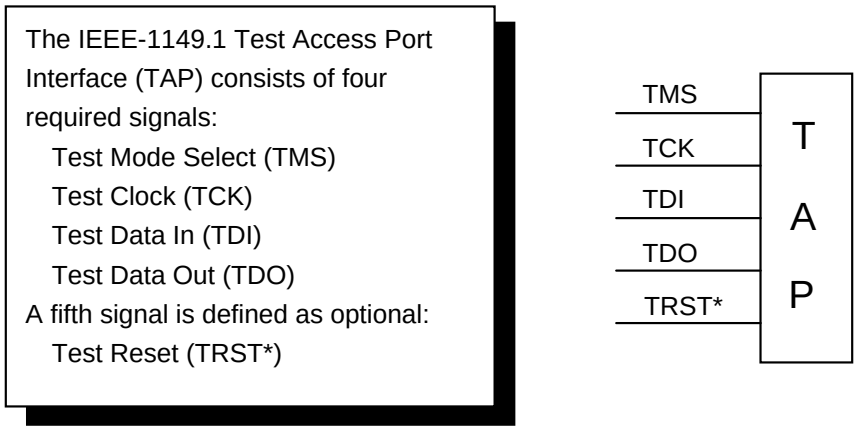

Figure 1-2. Minimal Test Access Port

TAP Expander Features

Adjustable Voltage Levels

The software-programmable voltage level of the TAP interfaces can be set to any voltage between 1.25 V and 3.30 V in increments of about 0.05V. The TI TAP and TAPs 1-3 use the same adjustable TAP voltage setting.

When set to "Automatic", the TAP Expander sets the TAP voltage to match the voltage sensed on TVD (pin 5) of the TI DSP TAP connector.

Discrete Input/Output Signals

The TAP Expander operates three discrete input/output signals per TAP (1, 2, 3) under software control. These attach to the target TAP connector. They are driven or sensed as directed by software, in coordination with the scanning operation. Each such signal can be configured independently as TTL output or as input at the programmable voltage level. As outputs, these discretes are useful for providing control functions on the user target system such as general reset, power control, direct_write# pulse, disable/enable and/or similar signals for non-boundary-scan target stimulus.

Conversely, as inputs, they enable host sensing of the target to pace scanning activity or related conditions (such as a Flash ready/busy# signal).

TAP Expander Specifications

Blackhawk Emulator Interface (20-pin)

Emulator Connector	20-pin header, AMP part no. 1761607-7 or equivalent
Supported Emulator Cable	20-pin Compact TI (cTI) target connector

TI DSP TAP Interface (20-pin)

TAP Connector	20-pin header, AMP part no. 5-104549-2 or equivalent
Mating TAP Connector	20-pin IDC (flat cable), AMP part no. 1-111196-8 or equivalent
TAP Cable	20-pin to 20-pin (12”), Corelis P/N 15395-2

Corelis TAP Interfaces (20-pin)

TAP Connector	20-pin header, AMP part no. 5-104549-2 or equivalent
Mating TAP Connector	20-pin IDC (flat cable), AMP part no. 1-111196-8 or equivalent
TAP Cable	20-pin to 20-pin (12”), Corelis P/N 15392-2

Physical

Enclosure Dimensions	2.608 inches × 2.608 inches × 1.083 inches (± 0.02 inches) 66.25 mm × 66.25 mm × 27.50 mm (± 0.5 mm)

Power Requirements

TAP Expander draws its power (approximately 25mA) from an external 5V power supply.

Operating Environment

Temperature	0°C to 55°C
Relative Humidity	10% to 90%, non condensing

Storage Environment

Temperature	-40°C to 85°C

TAP Expander JTAG TAP Interface Specifications

Maximum TCK Frequency	50 MHz
Programmable Voltage (V_adj) Range	1.25V to 3.3V in 0.05V steps

TAP Expander Electrical Specifications

Symbol	Test Conditions	Limit Min	Limit Max	Units
V_{IH}	V_adj >= 2.7 V	2	V_adj + 0.5	V
	V_adj < 2.7 V	0.65 × V_adj	V_adj + 0.5	V
V_{IL}	V_adj >= 2.7		0.8	V
	V_adj <= 2.0		0.35 × V_adj	V
V_{OH}	I_{OH}= -12 mA	V_adj – 0.5		V
V_{OL}	I_{OL} = 12 mA		0.4	V

Table 1-1. TAP Expander DC and Switching Characteristics

TAP Expander LED

The green LED on top of the TAP Expander will illuminate to indicate the pod is receiving power from the required external 5V power supply. If the LED is not illuminated, the TAP Expander is not receiving power.

Chapter 2
TAP Expander Installation and Usage

When you receive the TAP Expander product it should contain the following items:

- TAP Expander Hardware Module
- TI DSP TAP Cable, 20-pin pin to 20-pin Cable (12 inch), Corelis P/N 15395-2
- Corelis TAP Cable, 20-pin to 20-pin Cable (12 inch), Corelis P/N 15392-2
- 5V Power Supply

Please ensure that all materials listed are present and free from visible damage or defects before proceeding. If anything appears to be missing or damaged, contact Corelis at the number listed on the title page immediately.

NOTE: The actual hardware shipped with the TAP Expander may vary depending on the customer order.

The following optional target interface cables are also available from Corelis:

- 20-pin to 10-pin TAP Adapter Cable, Corelis P/N 15390-2
- 20-pin to 16-pin TAP Adapter Cable, Corelis P/N 15391-2
- 20-pin to 20-pin TAP Adapter Cable, Corelis P/N 15392-2
- 20-pin to 14-pin EJTAG TAP Adapter Cable, Corelis P/N 15425
- 20-pin to 20-pin ARM TAP Adapter Cable, Corelis P/N 15432
- 20-pin to 15-pin ARC TAP Adapter Cable, Corelis P/N 15436
- 20-pin to 16-pin PowerPC TAP Adapter Cable, Corelis P/N 15433

The following optional TAP adapters are also available from Corelis:

- 14-pin Emulator to 20-pin Compact TI (cTI) Target Header Adapter, Corelis P/N 12111
- 14-pin Emulator to 60-pin High-density Target Header Adapter, Corelis P/N 12112
- 20-pin Compact TI (cTI) Emulator to 14-pin Target Header Adapter, Corelis P/N 12113
- 20-pin Compact TI (cTI) Emulator to 20-pin ARM Target Header Adapter, Corelis P/N 12114
- 20-pin Compact TI (cTI) Emulator to 60-pin High-density Target Header Adapter, Corelis P/N 12115

The Corelis TAP Expander module connects to the Blackhawk emulator through its captive ribbon cable. The connections between the components in a typical boundary-scan and functional test system are shown below in Figure 2-1.

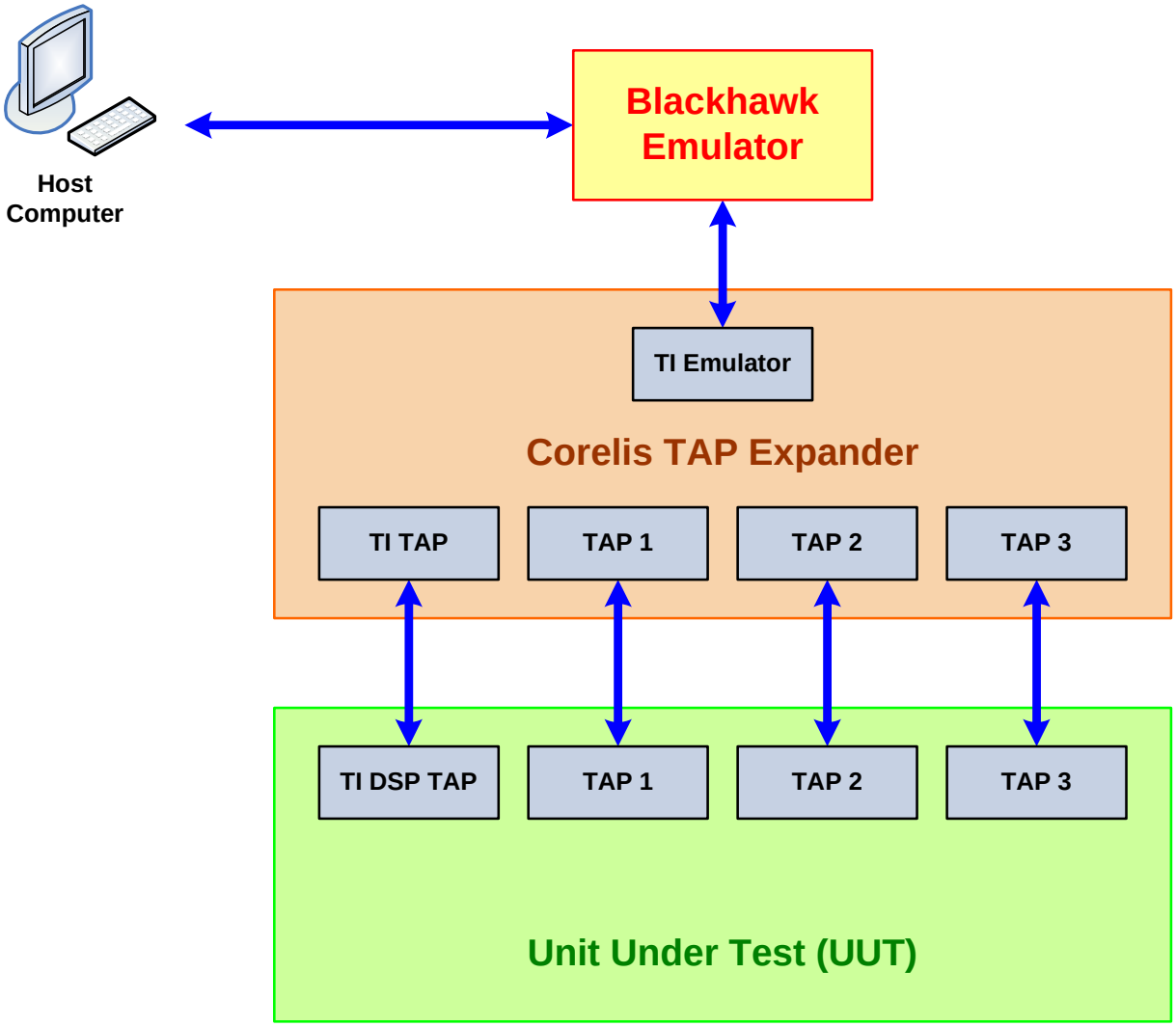

Figure 2-1. TAP Expander Connection Diagram

There are five TAP connectors on the TAP Expander. The Blackhawk emulator is connected to the TAP Expander through the connector marked **TI Emulator**. The connector marked **TI TAP** connects to the TI DSP TAP on the UUT used for emulation and functional testing. The connectors marked **TAP 1, TAP 2 and TAP 3** are used to connect to the other TAP connectors on the UUT.

The TAP Expander was designed to directly support the pinout of the Blackhawk emulator, TI DSP TAP and standard UUT TAP connectors with 1:1 cables.

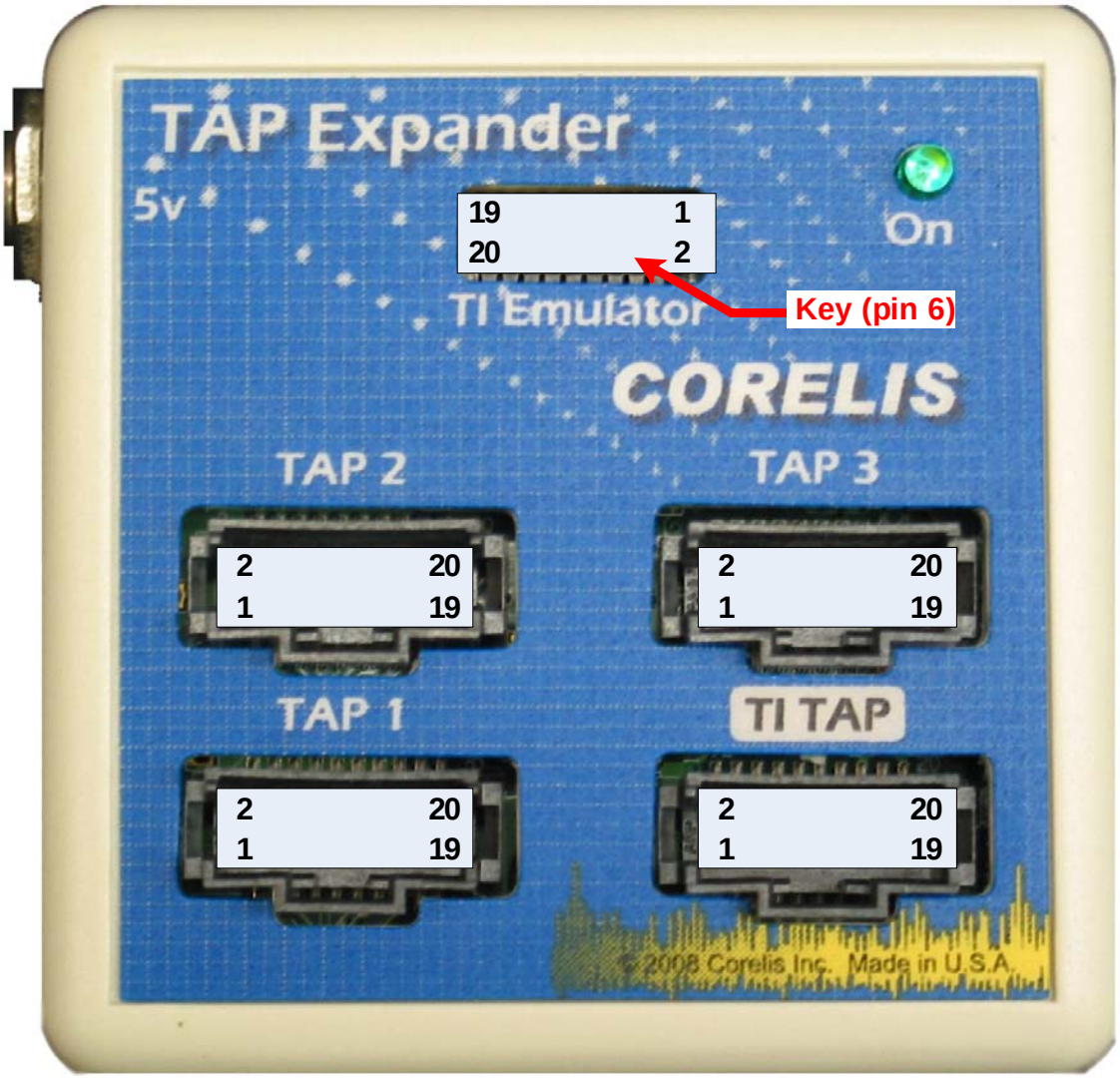

Figure 2-2. TAP Expander Connector Pin Numbering

Connecting to the Blackhawk Emulator

The Corelis TAP Expander module connects to the Blackhawk emulator through its captive ribbon cable.

The TAP Expander directly supports the Blackhawk controllers with a compact 20-pin JTAG connector. If the Blackhawk controller has a 14-pin JTAG connector, an adapter board (Corelis p/n *12111*) that converts the 14-pin connector on the emulator to a compatible 20-pin connector will need to be used. If the Blackhawk controller has a 60-pin JTAG connector, an adapter board that converts the 60-pin connector on the emulator to a compatible 20-pin connector will need to be used.

Supported Blackhawk JTAG Emulators

XDS560 Trace System

XDS560 Trace System [NOTE 1]

XDS560-class Models

USB560BP JTAG Emulator [NOTE 2]
LAN560 JTAG Emulator
PCI560 JTAG Emulator
USB560 JTAG Emulator

XDS510-class Models

USB510 JTAG Emulator [NOTE 2]
PCI510 JTAG Emulator [NOTE 2]
USB510L Controller [NOTE 2]
USB2000 Controller [NOTE 2]

NOTE 1: requires 60-pin high-density XDS560 Trace Module header to 20-pin Compact TI (cTI) target header adapter

NOTE 2: requires 14-pin JTAG connector to 20-pin Compact TI (cTI) target header adapter (Corelis part number 12111)

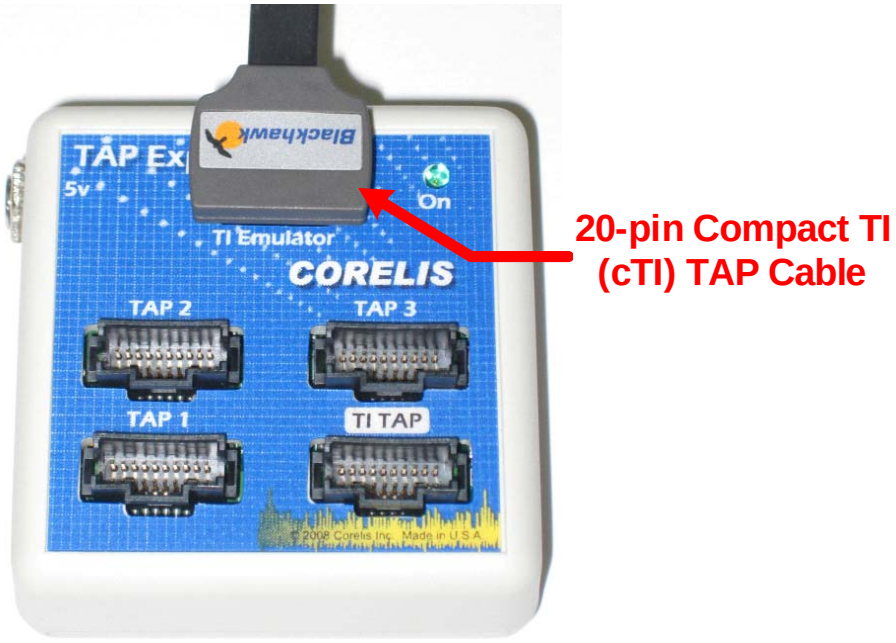

Figure 2-3. TAP Expander With 20-pin Cable

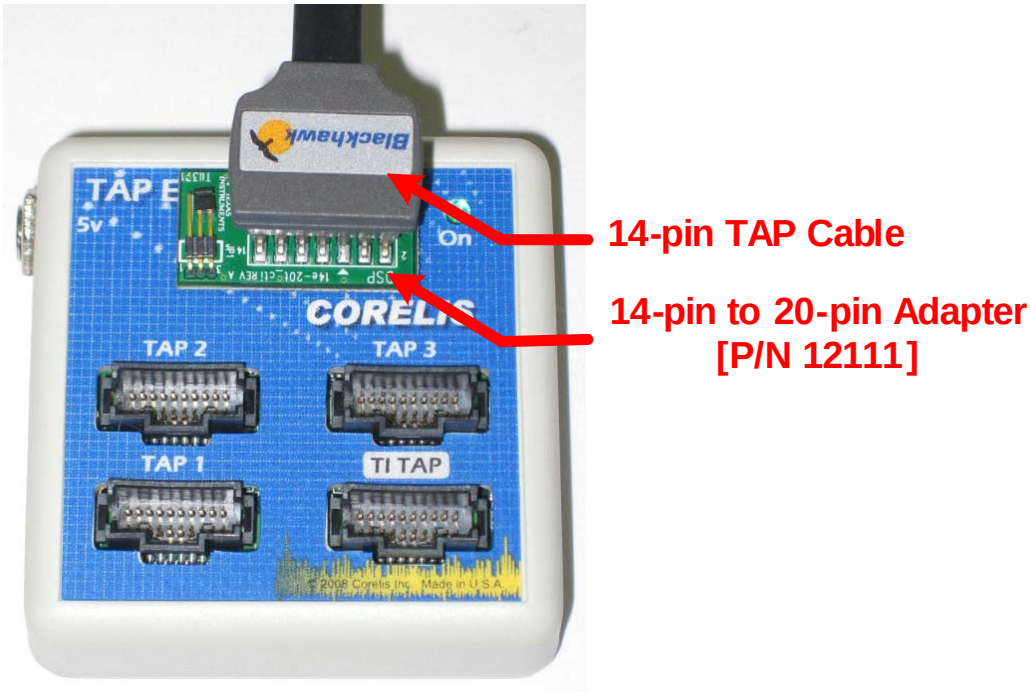

Figure 2-4. TAP Expander With 14-pin to 20-pin Cable Adapter

TI Emulator Connector Pinout (20-pin)

Pin	Signal Name	Signal Description
1	TMS	Test Mode Select
2	TRST*	Test Reset
3	TDI	Test Data Input
4	TDIS	
5	TVD	Target Voltage Detect
6	KEY	
7	TDO	Test Data Output
8	GND	
9	RTCK	Test Clock Return
10	GND	
11	TCK	Test Clock
12	GND	
13	EMU0	Emulation Pin 0
14	EMU1	Emulation Pin 1
15	SYSRST#	Reset (not used)
16	GND	
17	EMU2	Emulation Pin 2 (not used)
18	EMU3	Emulation Pin 3 (not used)
19	EMU4	Emulation Pin 4 (not used)
20	GND	

Table 2-1. 20-pin TI Emulator Connector Pinout

Connecting to the Unit Under Test (UUT)

The TAP Expander connects to the TI DSP TAP and other TAPs via ribbon cables. The following tables show the connector pinouts.

The TAP Expander directly supports TI DSP TAPs with a compact 20-pin JTAG connector. If the TI DSP TAP has a 14-pin JTAG connector, an adapter board (Corelis p/n *12113*) that converts the 20-pin connector on the TAP Expander cable to a compatible 14-pin connector will need to be used.

TI DSP TAP Connector Pinout (20-pin)

Pin	Signal Name	Signal Description
1	TMS	Test Mode Select
2	TRST*	Test Reset
3	TDI	Test Data Input
4	TDIS	
5	TVD	Target Voltage Detect
6	KEY	
7	TDO	Test Data Output
8	GND	
9	RTCK	Test Clock Return
10	GND	
11	TCK	Test Clock
12	GND	
13	EMU0	Emulation Pin 0
14	EMU1	Emulation Pin 1
15	SYSRST#	Reset (not used)
16	GND	
17	EMU2	Emulation Pin 2 (not used)
18	EMU3	Emulation Pin 3 (not used)
19	EMU4	Emulation Pin 4 (not used)
20	GND	

Table 2-2. 20-pin TI DSP TAP Connector Pinout

Corelis TAP Connector Pinout (20-pin)

Pin	Signal Name	Signal Description
1	TRST#	Test Reset
2	GND	
3	TDI	Test Data Input
4	GND	
5	TDO	Test Data Output
6	GND	
7	TMS	Test Mode Select
8	GND	
9	TCK	Test Clock
10	GND	
11	GPIO1 (direct_write#)	General Purpose I/O (flash programming direct_write#)
12	GND	
13	GPIO2	General Purpose I/O
14	GND	
15	GPIO3 (ready/busy#)	General Purpose I/O (flash programming ready/busy#)
16	GND	
17	VCC1	Target Voltage 1
18	GND	
19	VCC2	Target Voltage 2
20	GND	

Table 2-3. 20-pin Corelis TAP Connector Pinout

TAP Expander Usage

The TAP Expander is designed to transparently connect the Blackhawk emulator to the TI DSP TAP when first powered on until instructed to do otherwise. This allows the TAP Expander to remain connected between the Blackhawk emulator and the UUT when debugging with the TI Code Compose Studio software.

Setting Up the Blackhawk Emulator and TAP Expander

To set up the Blackhawk emulator and TAP Expander, go to the ScanExpress Runner main window. Select ***Controller*** from the ***Setup*** menu as shown in Figure 2-5**.**

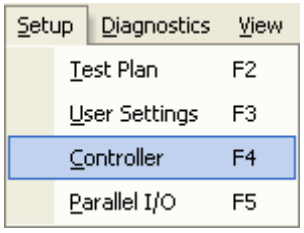

Figure 2-5. ScanExpress Runner Setup Menu

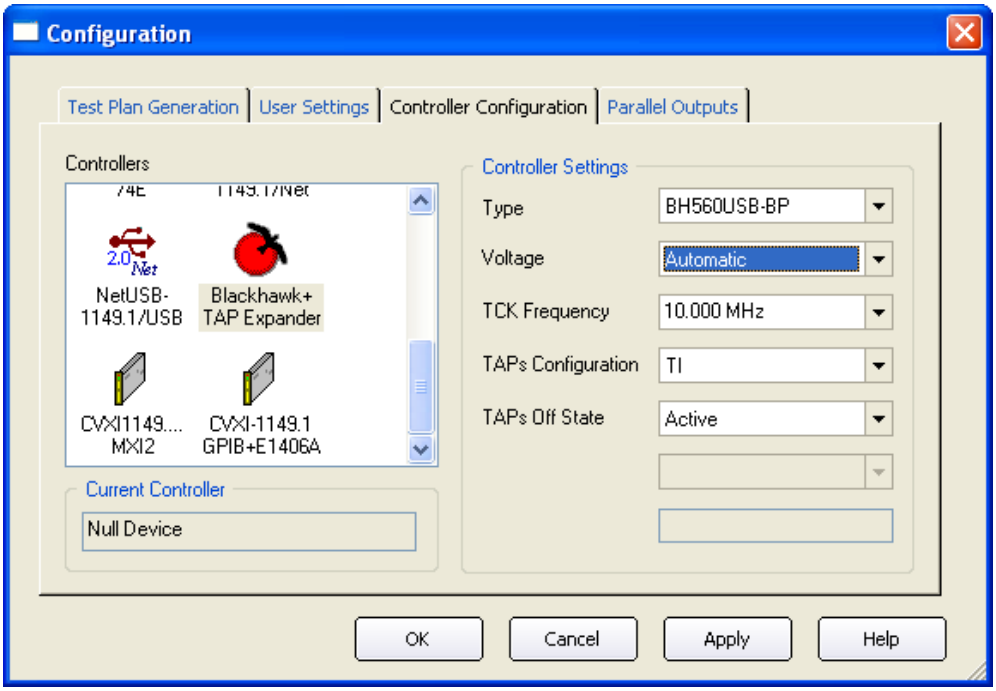

Figure 2-6. ScanExpress Runner Controller Configuration Dialog

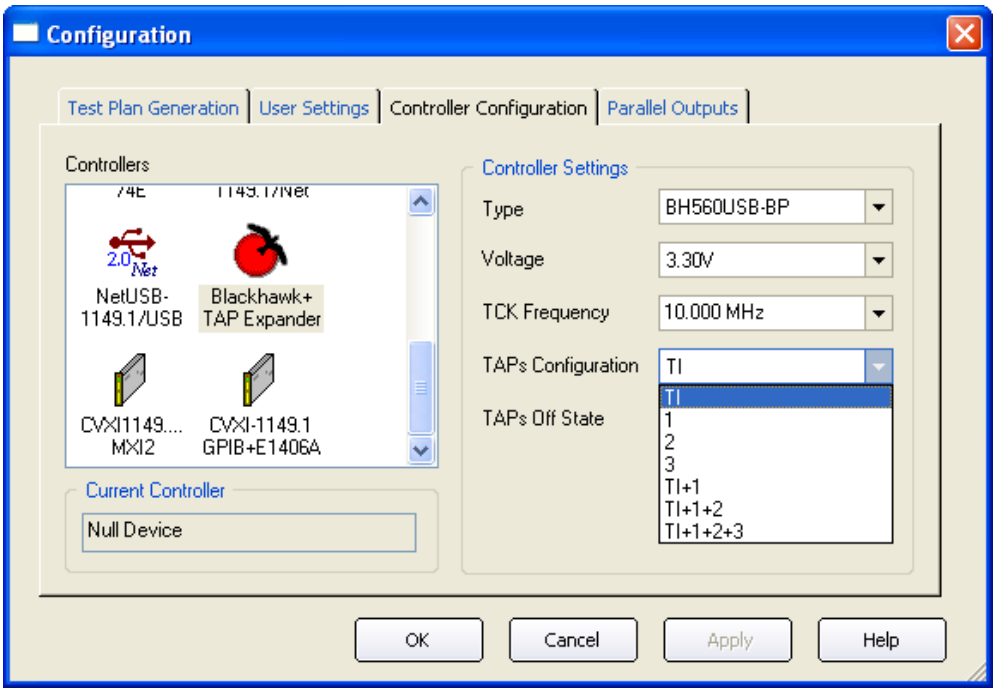

Figure 2-7. ScanExpress Runner Controller Configuration Dialog

Configuration	Meaning	TAP(s) Enabled
TI	Enable TI DSP TAP only	TI DSP TAP only
1	Enable TAP1 only	TAP1 only
2	Enable TAP2 only	TAP2 only
3	Enable TAP3 only	TAP3 only
TI + 1	Serialize TI DSP TAP and TAP 1	TI DSP TAP and TAP 1 in series
TI + 1 + 2	Serialize TI DSP TAP and TAPs 1 through 2	TI DSP TAP and TAPs 1, 2 in series
TI +1 + 2 + 3	Serialize TI DSP TAP and TAPs 1 through 3	TI DSP TAP and TAPs 1, 2, 3 in series

Table 2-4. TAP Expander Configuration in ScanExpress Runner

Appendix A
Recommended Target Connectors

TI DSP TAP Connector

See Table 2-2 for the recommended pinout for the TI DSP TAP connector.

10-pin TAP Connector

The Boundary-Scan TAP is a well defined IEEE-1149.1-compatible electrical interface between boundary-scan test equipment and the boundary-scan compatible devices in the user's target board. Boundary-scan based test equipment, such as the Corelis ScanExpress family of products, utilize a single TAP to interface to the UUT. This section explains how to implement a TAP connector that is compatible with most standard test equipment.

The TAP contains 5 signals: TCK, TMS, TDO, TDI and optionally TRST*. It also contains ground signal(s). Corelis recommends the standard TAP connector shown in Figure 2-8, which is widely regarded as the industry standard. Note that each signal is terminated with a resistor (discussed below) in order to improve noise immunity.

The connector on the user's target should have a standard flat cable compatible pinout to match the TAP connector described in Table 2-5. Figure 2-8 shows the top view of the basic target 10-pin connector header (0.100 × 0.100 in. spacing):

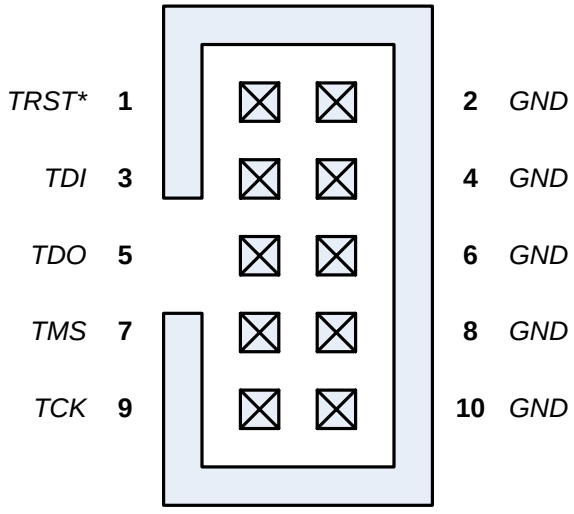

Figure 2-8. Standard TAP connector (top view)

Table 2-5 describes the 10-pin TAP connector signals and Corelis recommended values of terminating resistors:

Pin	Signal	Direction	Termination
1	TRST*	Input to the UUT	1K pull-up (or 1.5K pull-down)
2	GND		
3	TDI	Input to the UUT	1K pull-up
4	GND		
5	TDO	Output of the UUT	33 ohm series
6	GND		
7	TMS	Input to the UUT	1K pull-up
8	GND		
9	TCK	Input to the UUT	1K pull-up
10	GND		

Note: Some target boards may require a pull-down resistor on the TRST* signal to assure normal device operations when not in boundary-scan test mode.

Table 2-5. Signal Description and Termination

Table 2-6 summarizes the specifications for the 10-pin TAP connector. Equivalent connectors are available from other manufacturers.

Reference	Description	Manufacturer	Part Number
10-Pin Target TAP	Straight header, 10-pin, 4 wall, with center notch	3M	3473-6610

Table 2-6. Standard 10-Pin TAP Connector

Figure 2-9 shows a typical schematic of the target TAP connector with the recommended termination resistors. The 1K pull-up resistors should connect to the target Vcc supply corresponding to the interface voltage (programmable on the TAP Expander from 1.25 to 3.3 V). Recommended resistor values are +/- 5%.

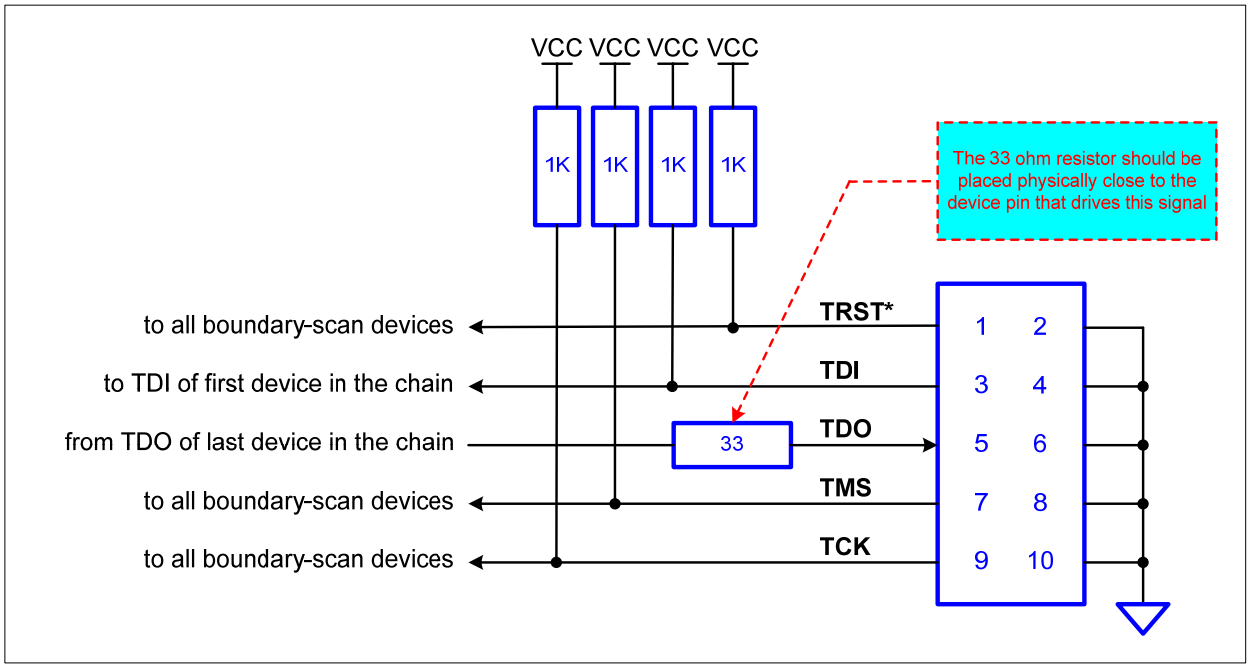

Figure 2-9. 10-pin TAP Connector Schematic

16-pin TAP Connector

To build in support for in-circuit programming of flash or microprocessor devices, Corelis recommends including supplemental control signals in the TAP interface. The ScanExpress Programmer can use a 16-pin TAP, similar to Figure 2-10, to improve programming time. This interface adds Write_Strobe*, Ready/Busy*, and ground signals to the standard 5-signal interface. Terminating resistors (see Table) can improve signal quality.

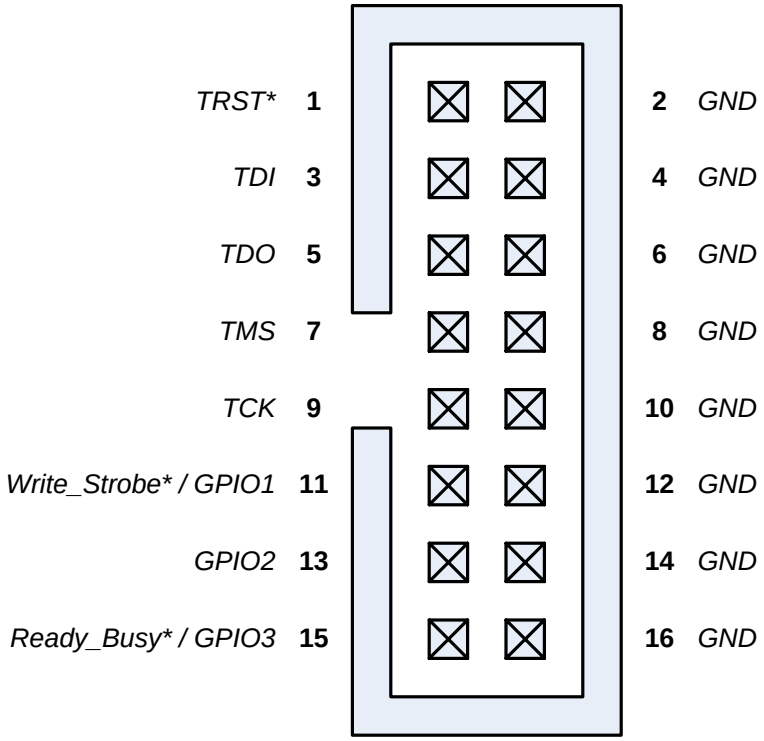

Figure 2-10. Boundary-scan Flash Programming 16-Pin TAP Connector (top view)

Corelis' Flash Programming software supports both the external write strobe signal (Write_Strobe*) and external Ready/Busy* signal.

(Write_Strobe*) and external Ready/Busy* signal. The Write_Strobe* signal is active low and should be pulled up with a 1K resistor on the target board. It needs to be logically ORed with the flash Write-Enable (WE*) signal so that either the flash Write-Enable (WE*) signal or the external Write_Strobe* going low will assert the flash WE* input.

The active low Ready/Busy* signal is typically an open-collector/open-drain signal that ties directly to the same signal(s) on the Flash device(s). This enables multiple devices to drive the signal towards the TAP Expander.

Table 2-7 summarizes the specifications for a 16-pin TAP connector without latch ejectors. Equivalent connectors are available from other manufacturers.

Reference	Description	Manufacturer	Part Number
Flash TAP	Straight header, 16-pin, 4 wall, with center notch	3M	2516-6002UG

Table 2-7. Flash Programming TAP 16-Pin Connector

Table 2-8 describes the signals and Corelis recommended values of terminating resistors:

Pin	Signal	Direction	Termination
1	TRST*	Input to the UUT	1K pull-up (or 1.5K pull-down)
2	GND		
3	TDI	Input to the UUT	1K pull-up
4	GND		
5	TDO	Output from UUT	33 ohm series
6	GND		
7	TMS	Input to the UUT	1K pull-up
8	GND		
9	TCK	Input to the UUT	1K pull-up
10	GND		
11	Write_Strobe*	Input to the UUT	1K pull-up
12	GND		
13	GPIO2		
14	GND		
15	Ready/Busy*	Output from UUT	1K pull-up
16	GND		

Note: Some target boards may require a pull-down resistor on the TRST* signal to assure normal device operations when not in boundary-scan test mode

Note: The target TDI signal is driven by the TDO signal of the boundary-scan controller

Note: The target TDO signal drives the boundary scan controller's TDI signal

Table 2-8. 16-pin Connector Signal Description and Termination

Figure 2-11 shows a typical schematic of the target TAP connector with termination resistors. The 1K pull-up resistors should connect to the target Vcc supply corresponding to the interface voltage (programmable on the TAP Expander from 1.25 to 3.3 V). Recommended resistor values are +/- 5%.

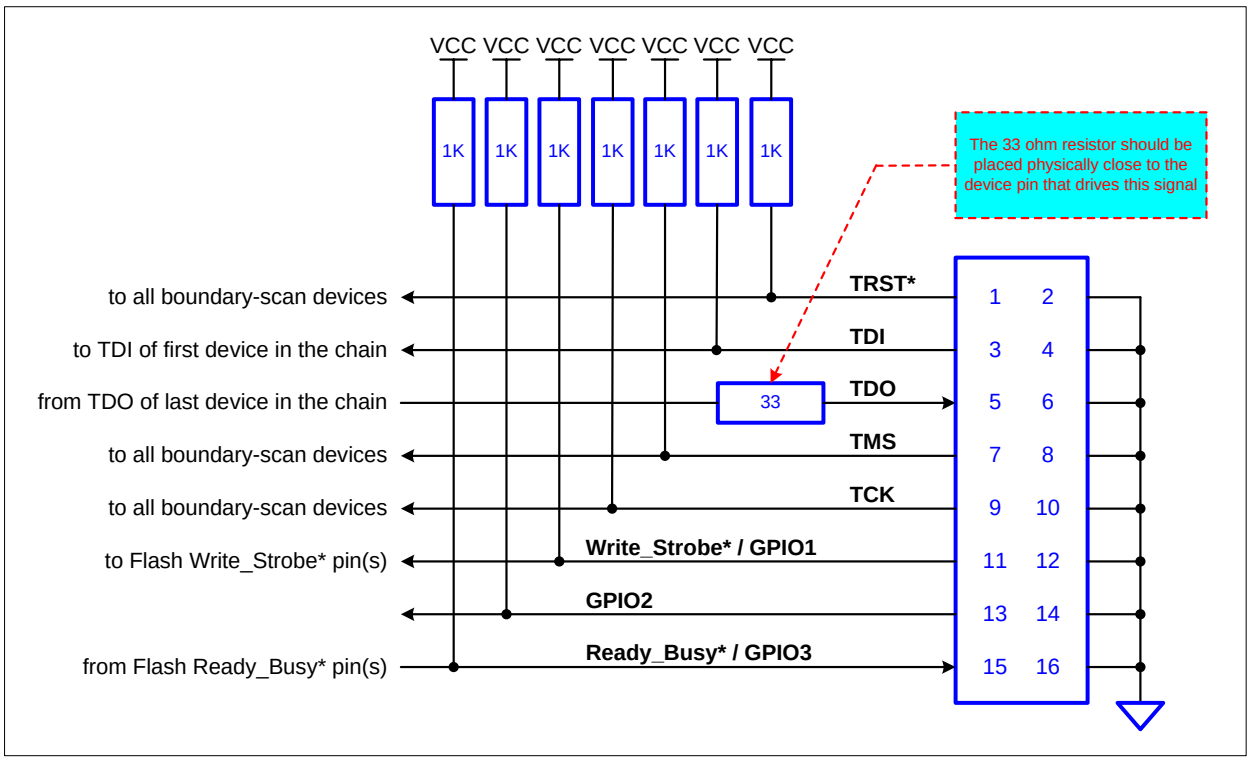

Figure 2-11. 16-pin Flash Programming TAP Connector Schematics

20-pin TAP Connector

To build in support for in-circuit programming of flash or microprocessor devices, Corelis recommends including supplemental control signals in the TAP interface. The ScanExpress Programmer can use a 20-pin TAP, similar to Figure 2-12, to improve programming time. This interface adds Write_Strobe*, Ready/Busy*, and ground signals to the standard 5-signal interface. Terminating resistors (see Table) can improve signal quality.

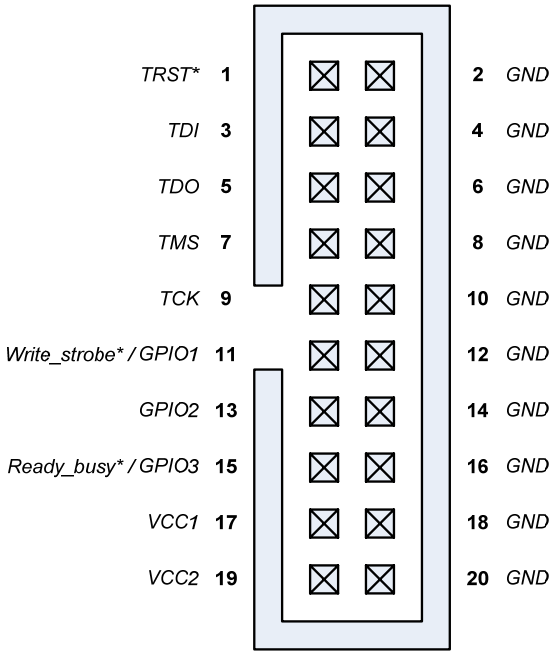

Figure 2-12. Boundary-scan Flash Programming 20-Pin TAP Connector (top view)

Corelis' Flash Programming software supports both the external write strobe signal (Write_Strobe*) and external Ready/Busy* signal.

The Write_strobe* signal is active low and should be pulled up with a 1K resistor on the target board. It needs to be logically ORed with the flash Write-Enable (WE*) signal so that either the flash Write-Enable (WE*) signal or the external Write_strobe* going low will assert the flash WE* input.

The active low Ready/Busy* signal is typically an open-collector/open-drain signal that ties directly to the same signal(s) on the Flash device(s). This enables multiple devices to drive the signal towards the TAP Expander.

Table 2-9 summarizes the specifications for a 20-pin TAP connector without latch ejectors. Equivalent connectors are available from other manufacturers.

Reference	Description	Manufacturer	Part Number
Flash TAP	Straight header, 20-pin, 4 wall, with center notch	3M	2520-6002UG

Table 2-9. Flash Programming TAP 20-Pin Connector

Table 2-10 describes the signals:

Pin	Signal Name	Signal Description
1	TRST*	Test Reset (Input to the UUT)
2	GND	
3	TDI	Test Data In (Input to the UUT)
4	GND	
5	TDO	Test Data Out (Output from the UUT)
6	GND	
7	TMS	Test Mode Select (Input to the UUT)
8	GND	
9	TCK	Test Clock (Input to the UUT)
10	GND	
11	Write_Strobe* / GPIO1	Discrete Output (Input to the UUT)
12	GND	
13	GPIO2	Discrete Output (Input to the UUT)
14	GND	
15	Ready_busy* / GPIO3	Discrete Input (Output from the UUT)
16	GND	
17	VCC1	Discrete Output (Input to the UUT)
18	GND	
19	VCC2	Discrete Output (Input to the UUT)
20	GND	

Table 2-10. TAP Expander 20-pin Target Connector Pin Assignment

Figure 2-13 shows a typical schematic of the target TAP connector with termination resistors. The 1K pull-up resistors should connect to the target Vcc supply corresponding to the interface voltage (programmable on the TAP Expander from 1.25 to 3.3 V). Recommended resistor values are +/- 5%.

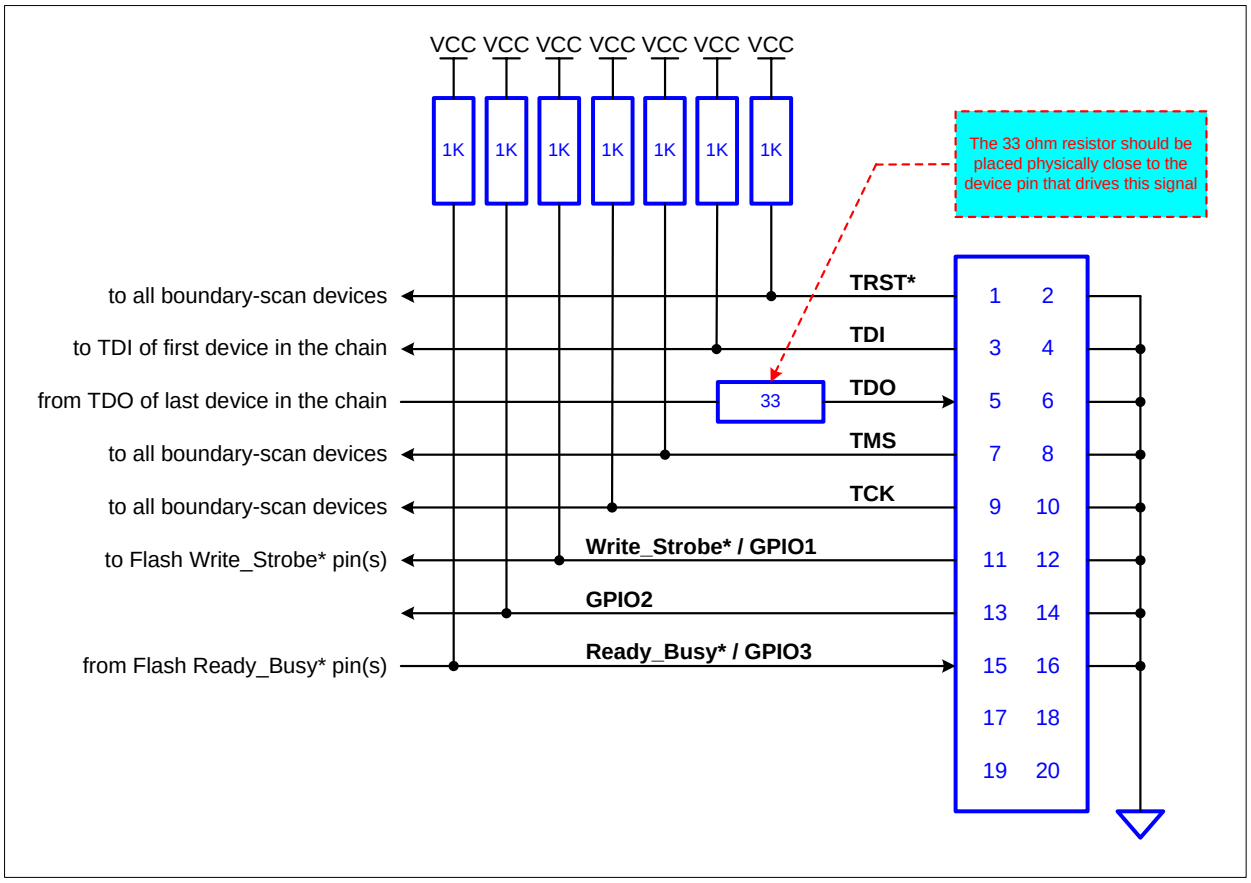

Figure 2-13. 20-pin TAP Connector Schematic for JTAG

Appendix B
Self Test & Configuration Utility Software

The TAP Expander comes with a self test and configuration utility that can be used to test the unit and configure it for use with third party software. The configuration utility is not necessary when using the TAP Expander with the ScanExpress family of boundary-scan and functional test software (Runner, Debugger, Programmer, JET, etc.).

The Blackhawk controller should be connected to the host computer and connected to the TAP Expander before running the software. The TAP Expander should also have its power supply connected before the software is started.

Using Windows Explorer, select and run the file "**TAP_Expander_test.exe**". A pop-up window will appear.

Configure

The upper group of options is used to configure the TAP Expander hardware for use with third party software like Code Composer Studio.

Blackhawk Controller Type – selects the Blackhawk controller that will be used with the TAP Expander.

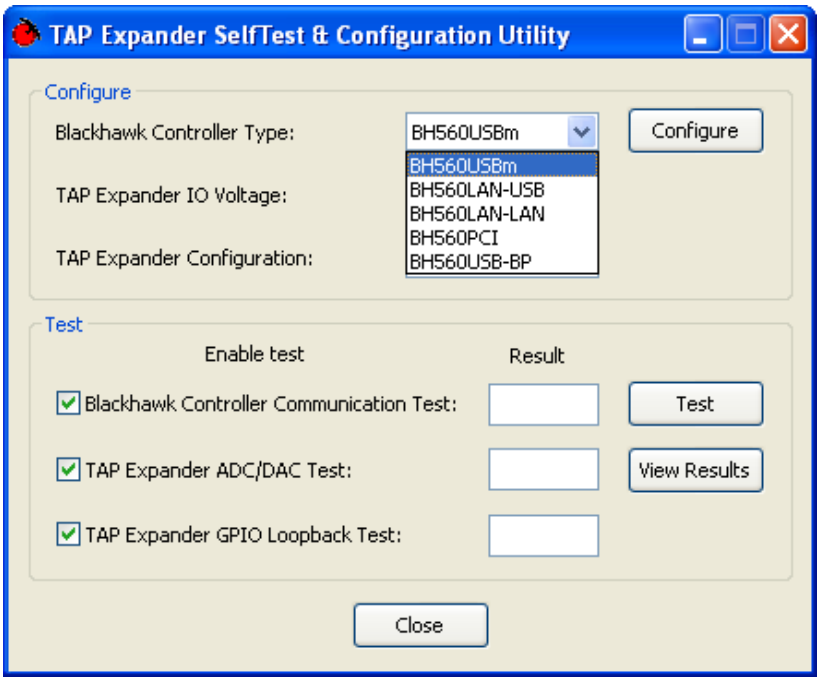

Figure 2-14. TAP Expander Controller Type Configuration

TAP Expander IO Voltage – sets the interface voltage for the TAP Expander. The voltage is the same for all four TAP interfaces (TI TAP, TAP 1, TAP 2, TAP 3). If the voltage is set to automatic the TAP Expander will read the voltage from the target TVD (Target Voltage Detect) and set the TAP interface voltage to match.

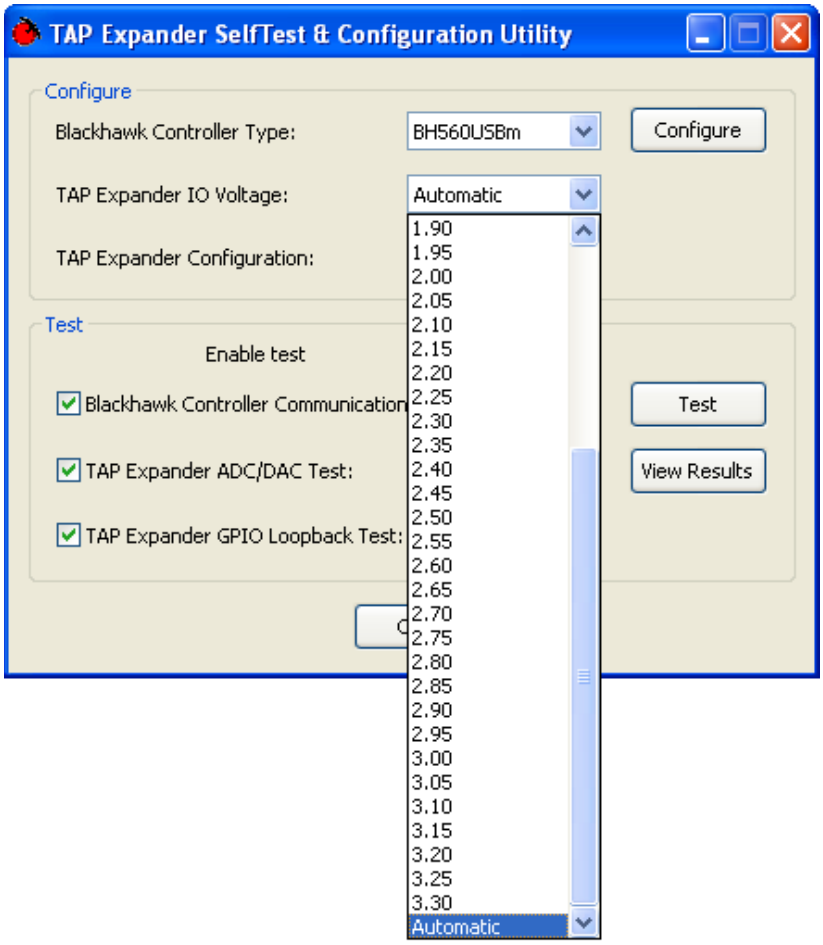

Figure 2-15. TAP Expander Voltage Interface

TAP Expander Configuration – sets the TAP chaining configuration for the TAP Expander. Should typically be set to "TI" (TI TAP) when used with third party software.

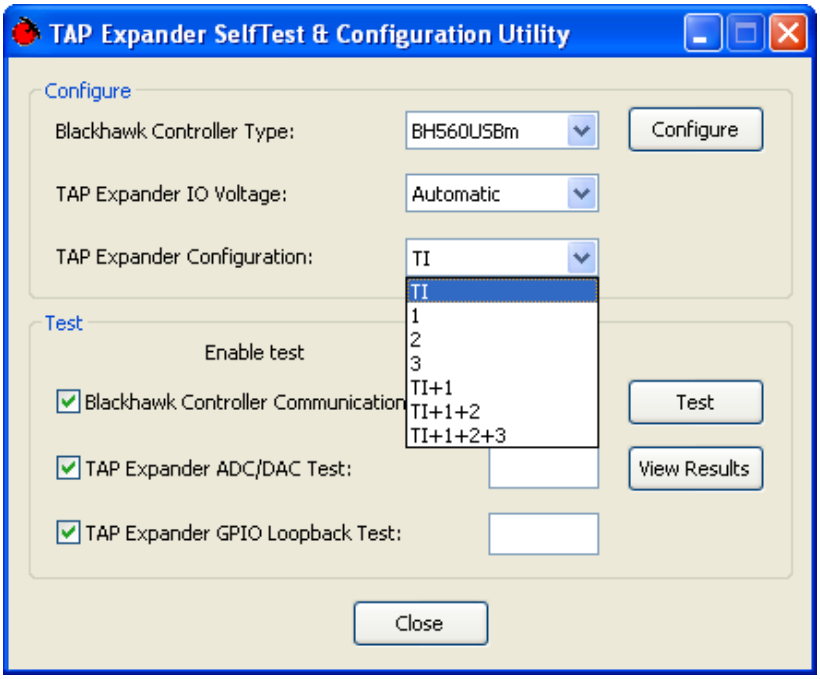

Figure 2-16. TAP Expander TAP Chaining Configuration

Test

The self-test utility is provided as an off-line confidence test only. Under normal circumstances there is no need to run the self-test utility software. However, if you suspect that the TAP Expander product is damaged, you can run the self-test on the module. Make sure to disconnect any target cables before running the test.

Step 1 Remove any target cables from the TAP Expander connectors (TI TAP, TAP 1, TAP 2, TAP 3)

Step 2 The Blackhawk controller and the TAP expander should both be plugged in and powered on.

Step 3 Set the "**Blackhawk Controller Type**" to the appropriate values "**TAP Expander IO Voltage**" and "**TAP Expander Configuration**".

Step 4 Click the "**Test**" button to execute the self test.

The program should respond with results similar to the screen shown in Figure 2-17.

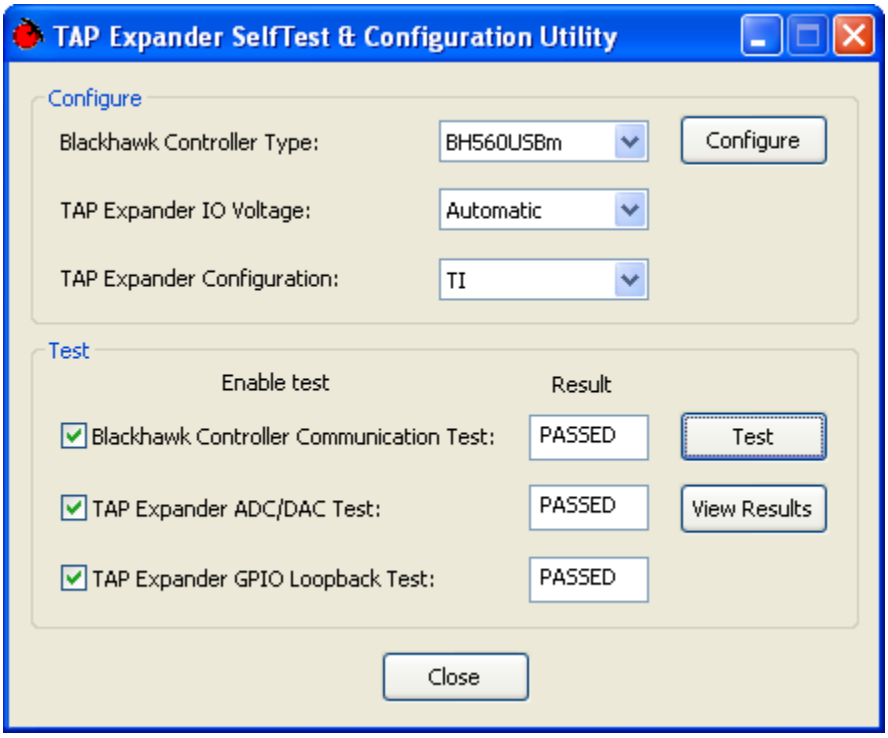

Figure 2-17. Self Test Results for the TAP Expander